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BROAD SCAN ANALYSIS OF THE FY82 NATIONAL HUMAN ADIPOSE TISSUE SURVEY SPECIMENS

VOLUME I - EXECUTIVE SUMMARY

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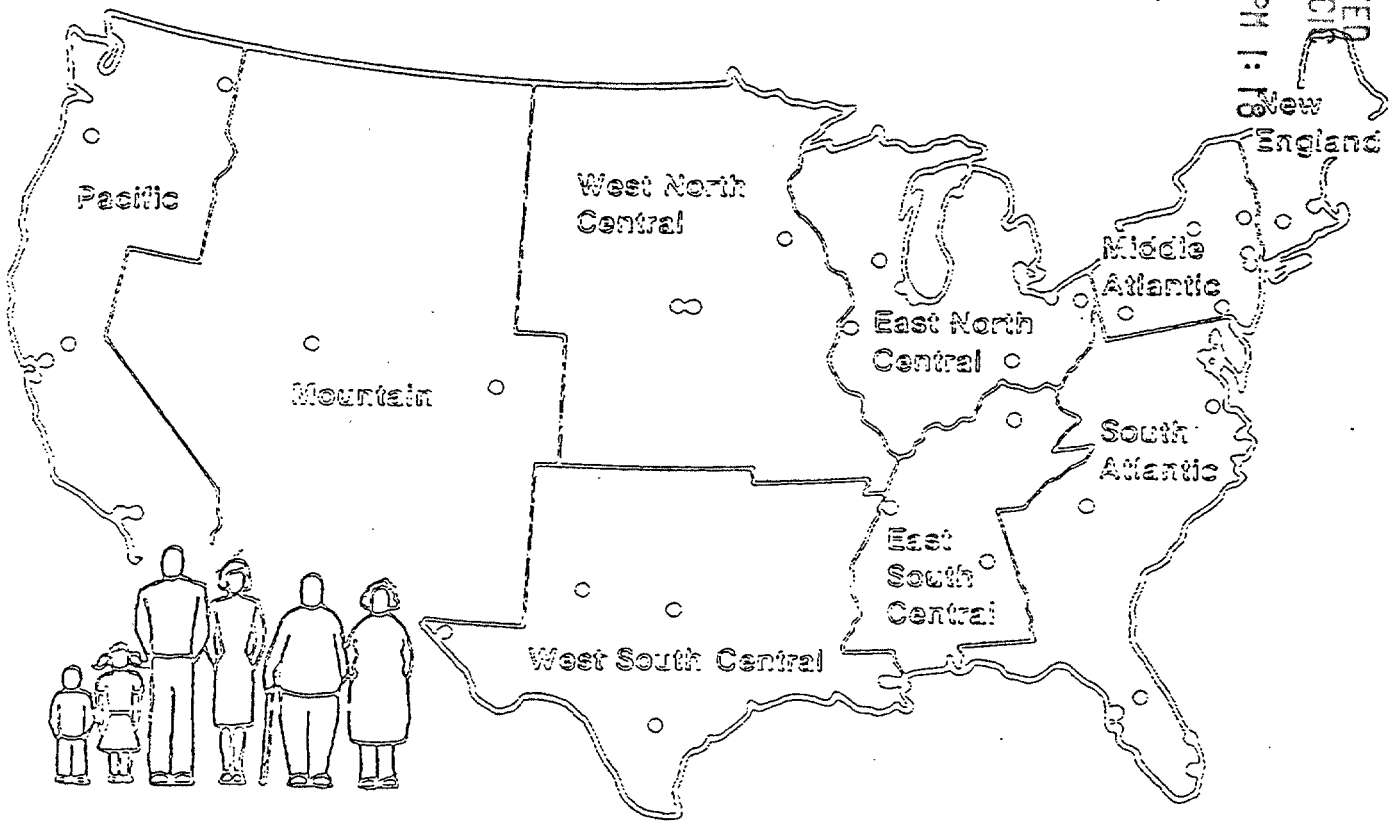

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16. ABSTRACT

The National Human Adipose Tissue Survey (NHATS) provides the U.S. EPA with a unique capability for monitoring human exposure to potentially toxic substances that persist in the environment. NHATS is an annual program to collect and chemically analyze adipose tissues from a cross-section of the general U.S. population. Historically, the analysis of the tissues has focused on PCBs and organochlorine pesticides. EPA's Office of Toxic Substances (OTS) has developed an aggressive approach to provide a comprehensive assessment of potentially toxic substances in human adipose tissue.

A broad scan analysis concept was introduced beginning with specimens collected in fiscal year 1982. The tissues were analyzed as composites based on the nine U.S. Census divisions and three age groups. The composites were analyzed for volatile and semivolatile organics at the parts per billion level and PCDD and PCDF at the parts per trillion level. Several tissue samples were analyzed by individually coupled plasma-atomic emission spectroscopy (ICP-AES) and neutron activation analyses (NAA). This report provides a synopsis of each of these analytical efforts.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Human Adipose Tissue Volatile Organic Compounds Semivolatile Organic Compounds Polychlorinated Dibenzo-p-dioxins (PCDD) Polychlorinated Dibenzofurans (PCDF) PCB HRGC/MS Inductively-coupled plasma-atomic emission spectroscopy neutron activation analysis	Analysis	

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BROAD SCAN ANALYSIS OF HUMAN ADIPOSE TISSUE: VOLUME 1: EXECUTIVE SUMMARY

by

John S. Stanley

FINAL REPORT

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PREFACE

This executive summary is the first of a five-volume series that details the broad scan chemical analysis of composite adipose tissue samples. These composite samples were prepared from individual specimens obtained from the Environmental Protection Agency's (EPA) National Human Adipose Tissue Survey (NHATS) fiscal year 1982 (FY82) repository.

This first volume summarizes data generated from all analysis efforts. Volumes II through V deal specifically with the chemical analysis of the NHATS composites. The statistical analyses of the data reported in these volumes will be reported separately by the EPA's Office of Toxic Substances (OTS) Design and Development Branch contractor, Battelle Columbus Laboratories.

The entire series of reports are referenced as follows:

- Stanley JS. 1986. Broad scan analysis of human adipose tissue: Volume I: Executive summary. EPA 560/5-86-035.
- Stanley JS. 1986. Broad scan analysis of human adipose tissue: Volume II: Volatile organic compounds. EPA 560/5-86-036.
- Stanley JS. 1986. Broad scan analysis of human adipose tissue: Volume III: Semivolatile organic compounds. EPA 560/5-86-037.
- Stanley JS. 1986. Broad scan analysis of human adipose tissue: Volume IV: Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) EPA 560/5-86-038.
- Stanley JS, Stockton RA. 1986. Broad scan analysis of human adipose tissue: Volume V: Trace elements. EPA 560/5-86-039.

These method development, sample analyses, and reporting activities were completed for the EPA/OTS Field Studies Branch (FSB) broad scan analysis of human adipose tissue program (EPA Prime Contract Nos. 68-02-3938 and 68-02-4252, Work Assignments 8 and 21, respectively, Ms. Janet Remmers, Work Assignment Manager, and Dr. Joseph Breen, Project Officer).

The samples were prepared with the assistance of Ms. Leslie Moody and Mr. Steven Turner. The HRGC/MS methods development and sample analyses were conducted by Mr. Steven Turner, Ms. Kathy Boggess, Mr. John Onstot, and Dr. Thomas Sack. The compositing scheme used to prepare the samples from the NHATS repository was provided by Dr. Gregory Mack, Battelle Columbus Laboratories, under contract to the EPA/OTS Design and Development Branch (Mr. Philip Robinson, Task Manager, and Ms. Cindy Stroup, Program Manager).

MIDWEST RESEARCH INSTITUTE

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I. INTRODUCTION

The U.S. Environmental Protection Agency's Office of Toxic Substances (EPA/OTS) maintains through the National Human Adipose Tissue Survey (NHATS) a unique program for estimating the general population exposure to toxic organic chemicals. NHATS is the main operative program of the National Human Monitoring Program (NHMP). The NHMP was first established by the U.S. Public Health Service in 1967, and was subsequently transferred to EPA in 1970. During 1979 the program was transferred within EPA to the Exposure Evaluation Division of OTS.

NHATS is an annual program to collect and chemically analyze a nationwide sample of adipose tissue specimens for the presence of toxic compounds. The objective of the program is to detect and quantify the prevalences of toxic compounds in the general population. The specimens are collected from autopsied cadavers and surgical patients according to a statistical survey design (Lucas 1981). The design ensures that specified geographic regions and demographic categories are appropriately represented to permit valid and precise estimates of baseline levels, time trends, and comparisons across subpopulations.

The NHATS data are used to address part of OTS's mandate under the Toxic Substances Control Act (TSCA) to assess chemical risk to the U.S. population. Historically, organochlorine compounds and polychlorinated biphenyls (PCBs) have been selected for evaluation.

A. Broad Scan Analysis Strategy

EPA/OTS has developed an aggressive strategy to expand the use of the NHATS program so as to provide a more comprehensive assessment of TSCA-related substances that persist in the adipose tissue of the general U.S. population. The NHATS specimens collected during fiscal year 1982 (FY82) were selected for a broad scan analysis of volatile and semivolatile organic TSCA-related chemicals and trace elements (Mack and Stanley 1984).

The initiative to achieve a more comprehensive assessment necessitated either the development of new methods or the modification of the existing analytical procedures. Data reported on NHATS specimens up to the FY82 collection are limited to organochlorine pesticides and PCBs based on packed column gas chromatography/electron capture detector (PGC/ECD) analysis.

B. Work Assignment Objectives

The objectives of this work assignment were (1) to identify appropriate analytical methods for a broad scan analysis of human adipose tissue based on high resolution gas chromatography/mass spectrometry (HRGC/MS) detection for general semivolatile and volatile organic compounds and multielemental techniques [neutron activation analysis (NAA) and inductively coupled emission spectrometry (ICP-AES)] for toxic trace elements; (2) to conduct preliminary evaluation of the analytical procedures; (3) to complete the sample workup and HRGC/MS analysis of 46 composite samples prepared from the NHATS specimens collected during FY82 (the target detection range for analytes by the HRGC/MS as specified in the current NHATS strategy (Mack and Stanley 1984) was 0.05

to 0.10 µg/g); and (4) to compare the data generated by the two multielemental techniques through the analysis of nine individual NHATS specimens.

The broad scan analysis approach is necessary to identify additional compounds or toxic trace elements that may be of concern to EPA under the mandates of TSCA. The multielemental analysis techniques were included as screening procedures to provide information on toxic trace elements that persist in human adipose tissue.

A summary of the results that were generated from the FY82 NHATS project is given in Section II. Recommendations for additional methods development are presented in Section III. Appendix A provides a glossary of the terms used throughout this text.

II. PROJECT SUMMARY

The broad scan analysis task has resulted in the development and preliminary evaluation of HRGC/MS methods for the measurement of volatile and semivolatile organic compounds at concentrations ranging from 0.001 to 2 µg/g in human adipose tissues. Procedures based on selected ion monitoring (SIM) techniques have provided qualitative analysis for complex analytes such as toxaphene. The sensitivity of the SIM technique has also been applied to the determination of parts per trillion (picogram/gram) quantities of specific polychlorinated dibenzo-p-dioxin (PCDD) and dibenzofuran (PCDF) congeners. Two multielement analysis techniques were evaluated to determine the levels of toxic trace elements in adipose tissue.

The results of this broad scan analysis activity have been presented in part at the American Chemical Society Symposium on "Exposure Measurement and Evaluation of Methods for Epidemiology Studies," Chicago, IL, September 1985; the Fifth International Dioxin Symposium in Bayreuth, FRG, September 1985 (Stanley et al. 1986); 13th Annual Federation of Analytical Chemistry and Spectroscopy Society Symposium on "Application of Mass Spectrometry in Trace Analysis," St. Louis, MO, in October 1986.

In addition to these reports and presentations, a detailed method protocol for the determination of specific semivolatile organic compounds in human adipose tissue was prepared and submitted for peer review (Stanley 1985). This analytical method is undergoing additional validation for implementation into the NHATS program for routine analysis.

The results of the method development and sample analysis activities are reported in four separate reports dealing specifically with volatile (Stanley 1986a), and semivolatile organics (Stanley 1986b), PCDDs and PCDFs (Stanley 1986c), and trace elements (Stanley and Stockton 1986). A synopsis of the results based on each analysis effort is presented.

A. Collection and Storage of NHATS Specimens

The adipose tissue specimens were originally collected during FY82 (October 1, 1981, through September 30, 1982) for determination of organo-

chlorine pesticide and PCB residues. The specimens were collected during surgical procedures or as part of postmortem examinations. The cooperating physicians and pathologists were requested to acquire at least 5 g of high lipid adipose (subcutaneous, perirenal, or mesenteric), taking precautions to avoid contamination that might result in direct contamination from chemicals such as solvents, paraffin, disinfectants, preservatives, or plastics. The cooperators were given no specific instructions to avoid potential contamination that might arise from background contribution (airborne levels) of solvents or metals.

The adipose tissue specimens were sealed in glass jars and frozen (-20°C) following collection. The specimens were shipped in insulated coolers packed in dry ice. The FY82 specimens were originally received and stored at EPA's Toxicant Analysis Center at Bay St. Louis, MS. The NHATS repository was transferred to Midwest Research Institute (MRI) during September 1982. The specimens were shipped in insulated coolers and packed on dry ice. The specimens were inventoried at MRI upon receipt and were then stored in freezers (-20°C). Precautions were taken to ensure that the specimens remained frozen during all inventory and sample handling procedures. The procedures for preparation of the composite specimens are presented in detail in the report that focuses on the volatile organic analyses (Stanley 1986a).

B. Volatile Organic Compounds

An analytical method based on a heated dynamic headspace purge and trap technique was developed to sample volatile organic compounds from human adipose tissue. The volatile organic compounds were separated and detected using HRGC/MS. HRGC was selected to achieve the best possible separation of volatile components. MS was selected as a detector to provide the necessary specificity to positively detect the volatile compounds present in adipose tissue. Target analytes were quantitated based on a multiple internal standard technique. The method evaluation studies and daily quality control checks demonstrated that method accuracy was improved for analytes that had a corresponding deuterated analog as an internal quantitation standard.

Forty-six composite samples were prepared from the FY82 NHATS repository according to a study design prepared by the EPA/OTS Design and Development Branch contractor, Battelle Columbus Laboratories. The composite samples represent the nine U.S. census divisions stratified by three age groups (0-14, 15-44, and 45 plus).

The HRGC/MS analysis of the volatile compounds purged from the human adipose demonstrated a complex mixture of compounds consisting primarily of aldehydes, ketones, hydrocarbons, and carboxylic acid esters. Additional compounds that are classified as aromatic, halogenated aliphatic, and halogenated aromatic compounds were detected as minor constituents.

Quantitative data were determined for 17 specific compounds. The predominant target analytes that were noted in this study included chloroform, 1,1,1-trichloroethane, benzene, tetrachloroethene, toluene, chlorobenzene, ethylbenzene, styrene, 1,1,2,2-tetrachloroethane, 1,4-dichlorobenzene, 1,2-dichlorobenzene, xylenes, and ethylphenol.

Several compounds, including styrene, the xylene isomers, 1,4-dichlorobenzene, and ethylphenol, were detected in all composite samples. Table 1 presents the incidence of detection for the selected target analytes and the range of concentrations observed. Qualitative summaries of the incidence of detection based on age group and census division are presented in Tables 2 through 5.

The quantitative data for the 17 target analytes have been submitted along with all supporting quality control data to Battelle Columbus Division for statistical analysis. Characterization of additional chromatographic peaks in the HRGC/MS data to identify other compounds of interest to EPA has been initiated under a separate work assignment (Contract No. 68-02-4252, Work Assignment No. 23).

C. Semivolatile Organic Compounds

An analytical method for the broad scan analysis of human adipose tissue for semivolatile organic compounds was identified and evaluated. The analytical method is based on gel permeation chromatography (GPC), Florisil fractionation, and HRGC/MS. Figure 1 is a schematic of the sample preparation and analysis procedures.

Forty-six composite specimens were prepared from the FY82 NHATS repository according to a study design provided by Battelle Columbus Division, the EPA Design and Development Branch contractor. The composite specimens represent the nine U.S. census divisions stratified by three age groups (0-14, 15-44, and 45 plus).

Quantitative data for organochlorine pesticides, PCBs, chlorobenzenes, phthalate esters, phosphate triesters, and polynuclear aromatic hydrocarbons were determined for each composite. Table 6 summarizes the incidence of detection of selected semivolatile organic compounds and the range of concentrations measured based on extractable lipid content. Tables 7 through 10 qualitatively demonstrate the incidence of observation based on census divisions and age group. The feasibility of determining other halogenated aromatic compounds, including polybrominated biphenyls, polychlorinated terphenyls, and polychlorinated diphenyl ethers, using this method was demonstrated through the analysis of spiked adipose tissue samples.

The samples representing the 45-plus age category were also analyzed for toxaphene (a complex mixture of polychloroterpenes) by HRGC/MS-SIM. Toxaphene was qualitatively identified in 12 of the 14 samples analyzed. Quantitation of toxaphene was not achieved due to the complexity of the response but was estimated to be less than 0.10 μg/g.

Table 1. Incidence of Detection of Target Volatile Organic Compounds in the NHATS FY82 Composite Specimens

Compound	Frequency of observation (%)	Wet tissue concentration (ng/g)
Chloroform	76	ND (2)[a] - 580
1,1,1-Trichloroethane	48	ND (17) - 830
Bromodichloromethane	0	ND (21)
Benzene	96	ND (4) - 97
Tetrachloroethene	61	ND (3) - 94
Dibromochloromethane	0	ND (1)
1,1,2-Trichloroethane	0	ND (1)
Toluene	91	ND (1) - 250
Chlorobenzene	96	ND (1) - 9
Ethylbenzene	96	ND (2) - 280
Bromoform	0	ND (1)
Styrene	100	8-350
1,1,2,2-Tetrachloroethane	9	ND (1) - 8
1,2-Dichlorobenzene	63	ND (0.1) - 2
1,4-Dichlorobenzene	100	12-500
Xylene[b]	100	18-1,400
Ethylphenol	100	0.4-400

[a]ND = not detected. Value in parentheses is the estimated limit of detection.
[b]The exact isomers were not determined.

Table 2. Incidence of Detection of Volatile Organic Compounds in Composited Human Adipose Tissue from the Northeast Census Region

Census division:	New England			Middle Atlantic		
Age group:	0-14	15-44	45+	0-14	15-44	45+
Compound						
Chloroform	+	+	+	+-	++	++
1,1,1-Trichloroethane	-	+	-	--	++	--
Bromodichloromethane	-	-	-	--	--	--
Benzene	+	+	+	++	++	++
Tetrachloroethene	-	-	-	++	++	++
Dibromochloromethane	-	-	-	--	--	--
1,1,2-Trichloroethane	-	-	-	--	--	--
Toluene	+	+	+	++	++	++
Chlorobenzene	+	+	+	++	++	++
Ethylbenzene	+	+	+	++	++	++
Bromoform	-	-	-	--	--	--
Styrene	+	+	+	++	++	++
1,1,2,2-Tetrachloroethane	-	-	-	--	--	--
1,2-Dichlorobenzene	+	+	-	++	++	++
1,4-Dichlorobenzene	+	+	+	++	++	++
Xylene[a]	+	+	+	++	++	++
Ethylphenol	+	+	+	++	++	++

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

[a]The exact isomers were not determined.

Table 3. Incidence of Detection of Volatile Organic Compounds in Composited Human Adipose Tissue from the South Census Region

Census division:	South Atlantic			East South Central			West South Central		
Age group:	0-14	15-44	45+	0-14	15-44	45+	0-14	15-44	45+
Compound									
Chloroform	++	+++-	+++-	-	-+	--	-	++	-
1,1,1-Trichloroethane	-+	+++-	+++-	+	-+	-+	+	-+	-
Bromodichloromethane	--	----	----	-	--	--	-	--	-
Benzene	++	++++	++++	+	++	++	-	++	+
Tetrachloroethene	--	++++	-++-	-	++	-+	-	-+	-
Dibromochloromethane	--	----	----	-	--	--	-	--	-
1,1,2-Trichloroethane	--	----	----	-	--	--	-	--	-
Toluene	+-	++++	+++-	+	++	++	+	-+	+
Chlorobenzene	++	++++	-++-	+	++	++	+	++	+
Ethylbenzene	++	++++	++++	-	++	++	+	++	+
Bromoform	--	----	----	-	--	--	-	--	-
Styrene	++	++++	++++	+	++	++	+	++	+
1,1,2,2-Tetrachloroethane	--	----	---+	-	-+	-+	-	--	-
1,2-Dichlorobenzene	-+	-+--	----	+	-+	++	-	+-	+
1,4-Dichlorobenzene	++	++++	++++	+	++	++	+	++	+
Xylene[a]	++	++++	++++	+	++	++	+	++	+
Ethylphenol	++	++++	++++	+	++	++	+	++	+

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

[a]The exact isomers were not determined.

Table 4. Incidence of Detection of Volatile Organic Compounds in Composited Human Adipose Tissue from the North Central Census Region

Census division:	East North Central			West North Central		
Age group:	0-14	15-44	45+	0-14	15-44	45+
Compound						
Chloroform	++	+++	+++	-	+	++
1,1,1-Trichloroethane	--	-+-	--+	-	-	-+
Bromodichloromethane	--	---	---	-	-	--
Benzene	++	+++	++-	+	+	++
Tetrachloroethene	+-	-++	-++	+	+	++
Dibromochloromethane	--	---	---	-	-	--
1,1,2-Trichloroethane	--	---	---	-	-	--
Toluene	++	+++	+++	+	+	++
Chlorobenzene	++	+++	+++	+	+	++
Ethylbenzene	++	+++	+++	+	+	++
Bromoform	--	---	---	-	-	--
Styrene	++	+++	+++	+	+	++
1,1,2,2-Tetrachloroethane	--	+--	---	-	-	--
1,2-Dichlorobenzene	++	++-	+-+	+	-	+-
1,4-Dichlorobenzene	++	+++	+++	+	+	++
Xylene[a]	++	+++	+++	+	+	++
Ethylphenol	++	+++	+++	+	+	++

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

[a]The exact isomers were not determined.

Table 5. Incidence of Detection of Volatile Organic Compounds in Composited Human Adipose Tissue from the West Census Region

Census division:	Mountain			Pacific		
Age group:	0-14	15-44	45+	0-14	15-44	45+
Compound						
Chloroform	+	+	+	+	+	+
1,1,1-Trichloroethane	-	+	+	+	+	-
Bromodichloromethane	-	-	-	-	-	-
Benzene	+	+	+	+	+	+
Tetrachloroethene	-	-	+	-	+	+
Dibromochloromethane	-	-	-	-	-	-
1,1,2-Trichloroethane	-	-	-	-	-	-
Toluene	+	+	+	+	+	+
Chlorobenzene	+	+	+	+	+	+
Ethylbenzene	+	+	+	+	+	+
Bromoform	-	-	-	-	-	-
Styrene	+	+	+	+	+	+
1,1,2,2-Tetrachloroethane	-	-	-	-	-	-
1,2-Dichlorobenzene	-	+	+	+	+	+
1,4-Dichlorobenzene	+	+	+	+	+	+
Xylene[a]	+	+	+	+	+	+
Ethylphenol	+	+	+	+	+	+

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

[a]The exact isomers were not determined.

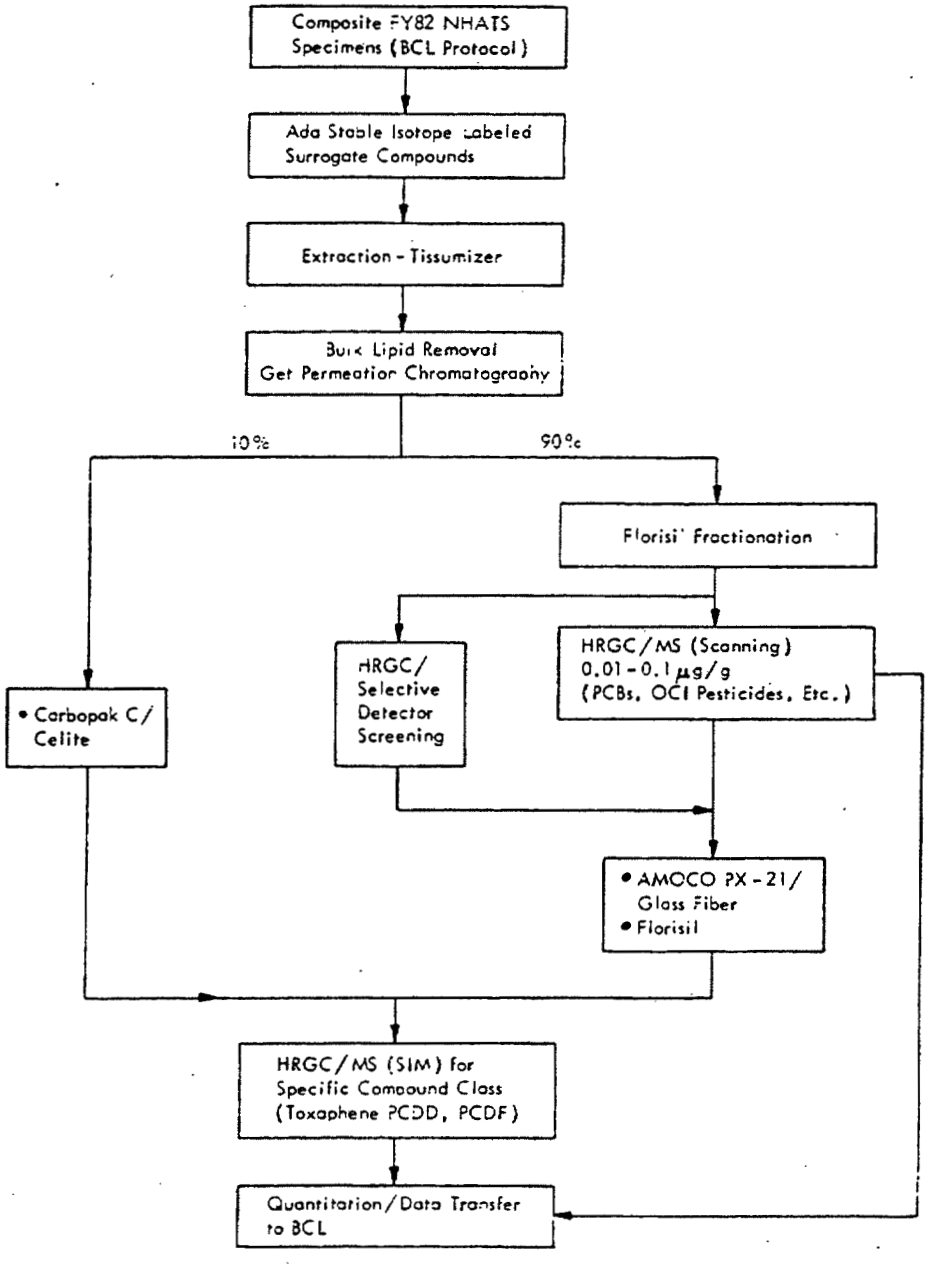

Figure 1. Flow scheme for analysis of semivolatile organic compounds in human adipose tissue.

Table 6. Incidence of Detection of Target Semivolatile Organic Compounds in the NHATS FY82 Composite Specimens

Compound	Frequency of observation (%)[a]	Range of observed lipid concentration (ng/g)
Dichlorobenzene	9	ND (9)[b] - 57
Trichlorobenzene	4	ND (9) - 21
Naphthalene	40	ND (9) - 63
Diethyl phthalate	42	ND (10) - 970
Tributyl phosphate	2	ND (44) - 120
Hexachlorobenzene	76	ND (12) - 1,300
β-BHC	87	ND (19) - 570
Phenanthrene	13	ND (9) - 24
Di-n-butyl phthalate	44	ND (10) - 1,700
Heptachlor epoxide	67	ND (10) - 310
trans-Nonachlor	53	ND (18) - 520
p,p'-DDE	93	ND (9) - 6,800
Dieldrin	31	ND (44) - 4,100
p,p'-DDT	55	ND (9) - 540
Butylbenzyl phthalate	69	ND (9) - 1,700
Triphenyl phosphate	36	ND (18) - 850
Di-n-octyl phthalate	31	ND (9) - 850
Mirex	13	ND (9) - 41
tris(2-Chloroethyl)phosphate	2	ND (35) - 210
Total PCBs	83	ND (15) - 1,700
Trichlorobiphenyl	22	ND (9) - 33
Tetrachlorobiphenyl	53	ND (9) - 93
Pentachlorobiphenyl	73	ND (21) - 270
Hexachlorobiphenyl	73	ND (19) - 450
Heptachlorobiphenyl	53	ND (19) - 390
Octachlorobiphenyl	40	ND (20) - 320
Nonachlorobiphenyl	13	ND (18) - 300
Decachlorobiphenyl	7	ND (22) - 150

[a] Sample size = 46 composites.
[b] ND = not detected. Value in parentheses is the estimated limit of detection.

Table 7. Incidence of Detection of Semivolatile Organic Compounds Determined in Composited Human Adipose Tissue from the West Census Region

Census division:	Mountain			Pacific	
Age group:	0-14	15-44	45+	0-14	45+
Compound					
Dichlorobenzene	-	-	-	-	-
Trichlorobenzene	-	-	-	-	-
Naphthalene	-	-	-	-	+
Diethyl phthalate	-	-	+	-	-
Tributyl phosphate	-	-	-	-	-
Hexachlorobenzene	-	+	+	+	+
β-BHC	-	+	+	+	-
Phenanthrene	-	-	-	-	-
Di-n-butyl phthalate	-	-	-	-	-
Heptachlor epoxide	-	-	+	-	-
trans-Nonachlor	-	-	+	-	-
p,p'-DDE	+	+	+	+	-
Dieldrin	-	-	-	-	-
p,p'-DDT	+	+	+	+	-
Butylbenzyl phthalate	-	+	+	-	+
Triphenyl phosphate	-	+	+	-	+
Di-n-octyl phthalate	-	-	-	-	+
Mirex	-	-	-	-	-
tris(2-Chloroethyl) phosphate	-	-	-	-	-
Total PCBs	-	+	+	-	+
Trichlorobiphenyl	-	-	-	-	-
Tetrachlorobiphenyl	-	-	+	-	-
Pentachlorobiphenyl	-	-	+	-	+
Hexachlorobiphenyl	-	+	+	-	+
Heptachlorobiphenyl	-	-	+	-	+
Octachlorobiphenyl	-	-	-	-	+
Nonachlorobiphenyl	-	-	-	-	+
Decachlorobiphenyl	-	-	-	-	-

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

Table 8. Incidence of Detection of Semivolatile Organic Compounds Determined in Composited Human Adipose Tissue from the Northeast Census Region

Census division:	New England			Middle Atlantic		
Age group:	0-14	15-44	45+	0-14	15-44	45+
Compound						
Dichlorobenzene	-	-	+	--	--	-+
Trichlorobenzene	-	-	-	--	--	--
Naphthalene	-	+	-	--	-+	-+
Diethyl phthalate	+	+	+	-+	+-	--
Tributyl phosphate	-	-	-	--	--	--
Hexachlorobenzene	-	+	+	++	++	+-
β-BHC	-	+	+	++	++	++
Phenanthrene	-	-	-	--	+-	--
Di-n-butyl phthalate	-	-	+	+-	++	++
Heptachlor epoxide	-	+	-	++	++	+-
trans-Nonachlor	-	+	-	++	++	+-
p,p'-DDE	+	+	+	++	++	++
Dieldrin	-	-	-	--	--	-+
p,p'-DDT	-	+	+	++	+-	-+
Butylbenzyl phthalate	-	-	-	-+	++	-+
Triphenyl phosphate	-	-	-	-+	-+	-+
Di-n-octyl phthalate	+	+	-	--	+-	-+
Mirex	-	+	+	--	--	--
tris(2-Chloroethyl) phosphate	-	-	-	--	--	--
Total PCBs	-	+	+	++	++	++
Trichlorobiphenyl	-	-	-	--	--	--
Tetrachlorobiphenyl	-	+	+	++	++	+-
Pentachlorobiphenyl	-	+	+	++	++	++
Hexachlorobiphenyl	-	+	-	++	++	++
Heptachlorobiphenyl	-	-	-	--	+-	-
Octachlorobiphenyl	-	-	+	--	--	--
Nonachlorobiphenyl	-	-	-	--	--	--
Decachlorobiphenyl	-	-	-	--	--	--

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

Table 9. Incidence of Detection of Semivolatile Organic Compounds Determined in Composited Human Adipose Tissue from the North Central Census Region

Census division:	East North Central			West North Central		
Age group:	0-14	15-44	45+	0-14	15-44	45+
Compound						
Dichlorobenzene	--	--+	---	-	-	--
Trichlorobenzene	--	---	--+	-	-	--
Naphthalene	--	+--	++-	+	-	+-
Diethyl phthalate	-+	-+-	-+-	-	+	++
Tributyl phosphate	-+	---	---	-	-	--
Hexachlorobenzene	--	++-	+++	+	+	+-
β-BHC	-+	+++	+++	+	+	++
Phenanthrene	-+	---	---	-	-	--
Di-n-butyl phthalate	-+	-+-	-++	+	-	-+
Heptachlor epoxide	-+	-++	+++	+	+	++
trans-Nonachlor	--	--+	-++	-	+	++
p,p'-DDE	++	+++	+++	+	+	++
Dieldrin	--	-+-	-++	+	+	+-
p,p'-DDT	-+	++-	---	-	-	+-
Butylbenzyl phthalate	++	-+-	+++	+	+	++
Triphenyl phosphate	-+	-+-	-+-	-	-	-+
Di-n-octyl phthalate	--	-+-	--+	-	-	+-
Mirex	--	---	---	-	-	--
tris(2-Chloroethyl) phosphate	--	---	---	-	-	--
Total PCBs	--	+++	+++	+	+	++
Trichlorobiphenyl	--	---	+++	-	-	+-
Tetrachlorobiphenyl	--	-+-	-++	-	+	++
Pentachlorobiphenyl	--	-++	-++	+	+	++
Hexachlorobiphenyl	--	-++	-++	+	+	++
Heptachlorobiphenyl	--	+--	-++	-	+	++
Octachlorobiphenyl	--	+--	-++	-	+	++
Nonachlorobiphenyl	--	---	---	-	-	+-
Decachlorobiphenyl	--	---	-+-	-	-	--

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

Table 10. Incidence of Detection of Semivolatile Organic Compounds Determined in Composited Human Adipose Tissue from the South Census Region

Census division:	South Atlantic			East South Central			West South Central		
Age group:	0-14	15-44	45+	0-14	15-44	45+	0-14	15-44	45+
Compound									
Dichlorobenzene	--	----	----	-	-	--	-	--	+
Trichlorobenzene	--	---+	----	-	-	--	-	--	-
Naphthalene	++	--+-	+-+-	-	+	-+	+	+-	-
Diethyl phthalate	--	-++-	-+--	+	+	--	+	+-	-
Tributyl phosphate	--	----	----	-	-	--	-	--	-
Hexachlorobenzene	+-	++++	+-++	+	+	++	-	++	+
β-BHC	++	++++	+-++	+	+	++	+	++	+
Phenanthrene	--	+-+-	----	+	-	+-	-	--	-
Di-n-butyl phthalate	-+	-++-	-+--	+	+	--	+	--	+
Heptachlor epoxide	+-	-+++	--++	+	+	++	-	++	+
trans-Nonachlor	+-	--++	--+-	+	+	++	-	++	+
p,p'-DDE	++	++++	++++	+	+	++	+	++	+
Dieldrin	--	-+--	++--	+	+	--	-	+-	+
p,p'-DDT	++	+++-	+--+	+	-	-+	+	--	+
Butylbenzyl phthalate	++	+++-	+++-	+	+	--	+	++	+
Triphenyl phosphate	-+	-+--	-+--	+	+	--	-	-+	+
Di-n-octyl phthalate	-+	----	--+-	-	+	--	+	+-	+
Mirex	--	+-+-	--+-	-	-	--	-	--	-
tris(2-Chloroethyl) phosphate	--	----	----	-	-	--	+	--	-
Total PCBs	+-	++++	++++	+	+	++	+	++	+
Trichlorobiphenyl	--	-+--	++-+	+	-	--	-	--	+
Tetrachlorobiphenyl	--	-+++	-+++	-	+	--	-	++	+
Pentachlorobiphenyl	+-	++++	++++	-	+	++	-	++	+
Hexachlorobiphenyl	+-	++++	-+++	+	+	-+	+	++	+
Heptachlorobiphenyl	--	++++	++++	+	+	++	-	++	+
Octachlorobiphenyl	--	--+-	++++	+	+	++	+	--	+
Nonachlorobiphenyl	--	----	---+	-	+	++	-	--	-
Decachlorobiphenyl	--	----	-+-+	-	-	--	-	--	-

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

This study greatly advances the NHMP's capability to monitor exposure to toxic organic chemicals. The data base for the number of specific xenobiotic organic compounds detected in adipose tissue is expanded. Organochlorine pesticides and PCBs have previously been monitored through PGC/ECD techniques. The HRGC/MS method, however, provides an additional confidence level for determination since identification is based on matching both retention time and mass spectra. In addition, the detail on PCB levels is expanded as a result of identifying specific degrees of chlorination (homologs) and providing quantitation of individual responses. Previous analyses for PCBs in the NHATS monitoring program based on the PGC/ECD method had resulted in semiquantitative data based on a single response.

The quantitative data for the target analytes have been submitted along with all supporting quality control data to Battelle Columbus Division for statistical analysis. Characterization of additional chromatographic peaks in the HRGC/MS data to identify other compounds of interest to EPA has been initiated under a separate work assignment (Contract No. 68-02-4252, Work Assignment No. 23).

D. PCDD and PCDF

The sample preparation was completed using techniques that isolate the PCDD and PCDF congeners from potential interferences. The isolation of the PCDDs and PCDFs was achieved using carbon-based chromatography columns. Two different carbon materials were used to complete the analysis for the full range of the tetra- through octachloro-PCDD and PCDF congeners. HRGC/MS operated in the SIM mode as required to detect compound concentrations ranging from less than 5 pg/g (for tetra- and pentachloro congeners) to greater than 1,000 pg/g for the octachloro dibenzo-p-dioxin.

Table 11 presents the frequency of detection, mean concentration, and lipid concentration range of detection for the tetra- through octachloro-PCDD and PCDF congeners. Tables 12 through 15 present a qualitative summary for the detection of PCDD and PCDF by census divisions and age groups.

The data in Table 11 indicate that the 2,3,7,8-TCDD was detected in 35 of the 46 composites with an average lipid-adjusted concentration of 6.2 ± 3.3 pg/g. The average concentration of the other PCDD compounds ranged from 33.5 pg/g for pentachlorodibenzo-p-dioxin (detected in 91% of the composites) up to 554 pg/g for octachlorodibenzo-p-dioxin (detected in 100% of the composites).

The data demonstrated some differences in PCDD levels for the three age groups evaluated (Figure 2). The PCDFs were generally detected less frequently and were present at lower concentration than the PCDDs. Obvious trends in the levels of the PCDF congeners with respect to age were not observed. The mean values for the PCDD and PCDF data from this study are comparable to work that has been reported for other studies on adipose tissue samples from the United States (Schecter and Ryan 1986; Ryan 1986) and Sweden (Nygren et al. 1985) (Figure 3).

Table 11. Lipid-Adjusted Concentration of PCDD and PCDF in the NHATS FY82 Composite Specimens

Compound	Frequency of detection (%)	Mean concentration[a] (pg/g)	Range of detection (pg/g)
2,3,7,8-TCDD	76	6.2 ± 3.3	ND (1.3)[c] - 14
1,2,3,7,8-PeCDD	91	43.5 ± 46.5	ND (1.3) - 5,000
HxCDD[b]	98	86.9 ± 83.8	ND (13) - 620
1,2,3,4,7,8,9-HpCDD	98	102 ± 93.5	ND (26) - 1,300
OCDD	100	694 ± 355	19 - 3,700
2,3,7,8-TCDF	26	15.6 ± 16.5	ND (1.3) - 660
2,3,4,7,8-PeCDF	89	36.1 ± 20.4	ND (1.3) - 90
HxCDF[b]	72	23.5 ± 11.6	ND (3.0) - 60
1,2,3,4,6,7,8-HpCDF	93	20.9 ± 15.0	ND (3.5) - 79
OCDF	39	73.4 ± 134	ND (1.2) - 890

[a]Mean concentration calculated using trace and positive quantifiable values.
[b]Reference compounds not available to specify isomers.
[c]ND = not detected. Value in parentheses is the estimated limit of detection.

Table 12. PCDD and PCDF Detected in the NHATS FY82 Composite Specimens from the Northeast Census Region

Census division:	New England			Middle Atlantic		
Age group:	0-14	15-44	45+	0-14	15-44	45+
Compound						
2,3,7,8-TCDD	-	+	-	+-	+-	-+
1,2,3,7,8-PeCDD	+	+	-	++	++	++
HxCDD	+	+	+	++	++	++
1,2,3,4,7,8,9-HpCDD	+	+	+	++	++	++
OCDD	+	+	+	++	++	++
2,3,7,8-TCDF	+	-	-	+-	+-	+-
2,3,4,7,8-PeCDF	-	+	-	++	++	++
HxCDF	-	-	+	-+	++	++
1,2,3,4,6,7,8-HpCDF	-	+	+	++	++	++
OCDF	-	+	+	+-	+-	+-

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

Table 13. PCDD and PCDF Detected in the NHATS FY82 Composite Specimens from the West Census Region

Census division:	Mountain			Pacific		
Age group:	0-14	15-44	45+	0-14	15-44	45+
Compound						
2,3,7,8-TCDD	-	+	+	-	+	+
1,2,3,7,8-PeCDD	+	+	-	+	+	+
HxCDD	+	+	+	+	+	+
1,2,3,4,7,8,9-HpCDD	+	+	+	+	+	-
OCDD	+	+	+	+	+	+
2,3,7,8-TCDF	+	-	-	-	+	+
2,3,4,7,8-PeCDF	+	+	+	+	+	+
HxCDF	-	+	+	-	+	-
1,2,3,4,6,7,8-HpCDF	+	+	+	+	+	-
OCDF	+	-	-	+	+	-

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

Table 14. PCDD and PCDF Detected in the NHATS FY82 Composite Specimens from the South Census Region

Census division:	South Atlantic			East South Central			West South Central		
Age group:	0-14	15-44	45+	0-14	15-44	45+	0-14	15-44	45+
Compound									
2,3,7,8-TCDD	++	+-+-	+-++	+	++	+-	+	+-	+
1,2,3,7,8-PeCDD	++	++-+	+-+-	+	++	+-	+	++	+
HxCDD	++	++++	++++	+	++	++	+	++	+
1,2,3,4,7,8,9-HpCDD	++	++++	++++	+	++	++	+	++	+
OCDD	++	++++	++++	+	++	++	+	++	+
2,3,7,8-TCDF	--	-+--	+---	-	--	--	-	--	-
2,3,4,7,8-PeCDF	++	+++-	+-+-	+	++	+-	+	+-	+
HxCDF	+-	++--	++++	+	++	++	+	+-	+
1,2,3,4,6,7,8-HpCDF	++	++++	+-++	+	++	++	+	++	+
OCDF	--	++--	----	+	+-	--	-	--	-

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

Table 15. PCDD and PCDF Detected in the NHATS FY82 Composite Specimens from the North Central Census Region

Census division:	East North Central			West North Central		
Age group:	0-14	15-44	45+	0-14	15-44	45+
Compound						
2,3,7,8-TCDD	-+	+++	-++	+	+	++
1,2,3,7,8-PeCDD	++	+++	-++	+	+	++
HxCDD	++	+++	+++	-	+	++
1,2,3,4,7,8,9-HpCDD	++	+++	+++	+	+	++
OCDD	++	+++	+++	+	+	++
2,3,7,8-TCDF	++	+--	---	-	-	--
2,3,4,7,8-PeCDF	++	+++	-++	+	+	++
HxCDF	-+	+++	+++	-	-	++
1,2,3,4,6,7,8-HpCDF	++	+++	+++	+	+	++
OCDF	++	+++	---	-	-	+-

Note: A positive (+) value indicates the compound was detected at a trace (response greater than 2.5 times S/N but less than 10 times S/N) or positive quantifiable level (response greater than 10 times S/N). A negative (-) value indicates the compound was not detected (response less than 2.5 times S/N). The number of symbols for each age group indicates the number of composites analyzed.

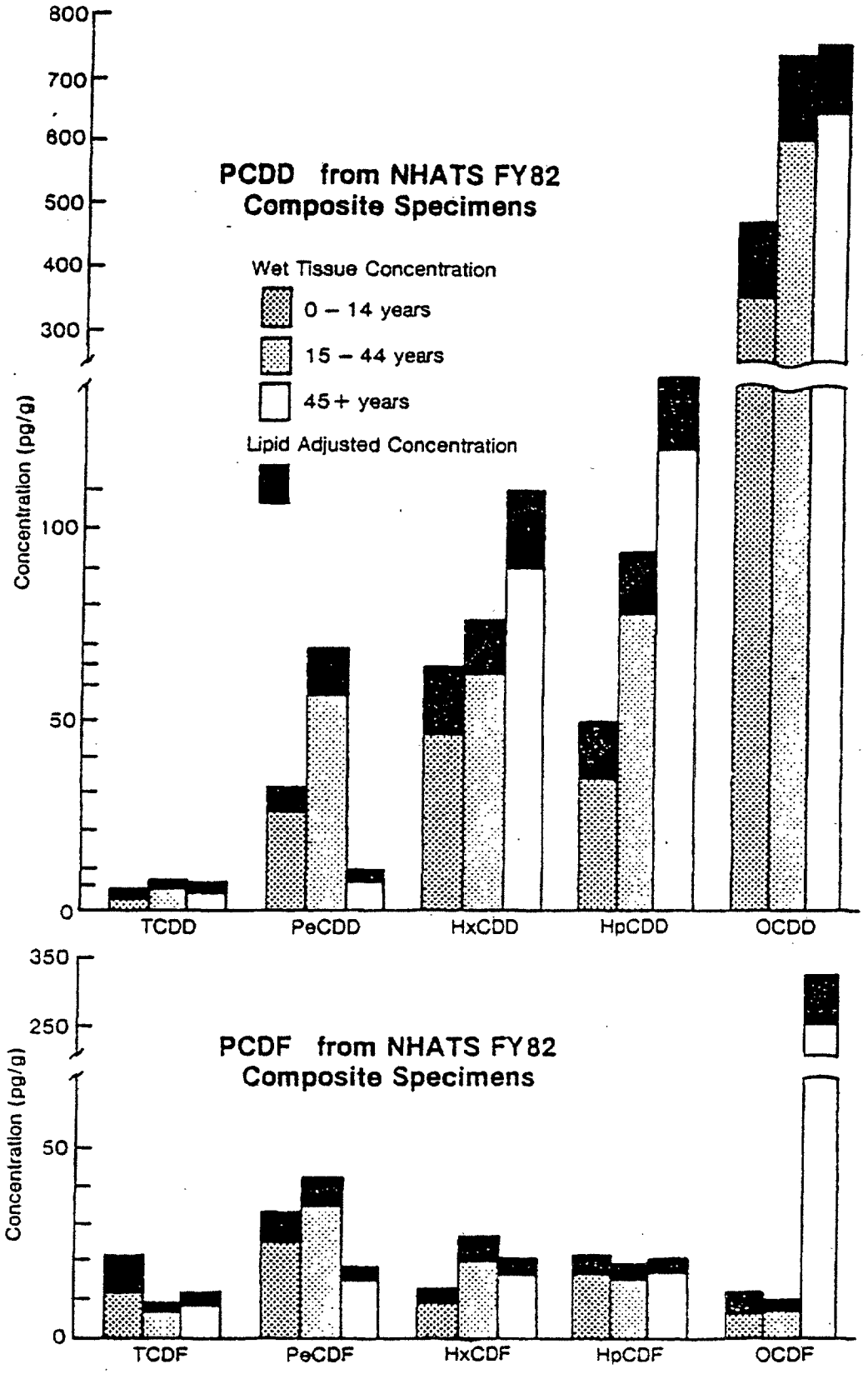

Figure 2. PCDD and PCDF distribution in the general U.S. population by age group.

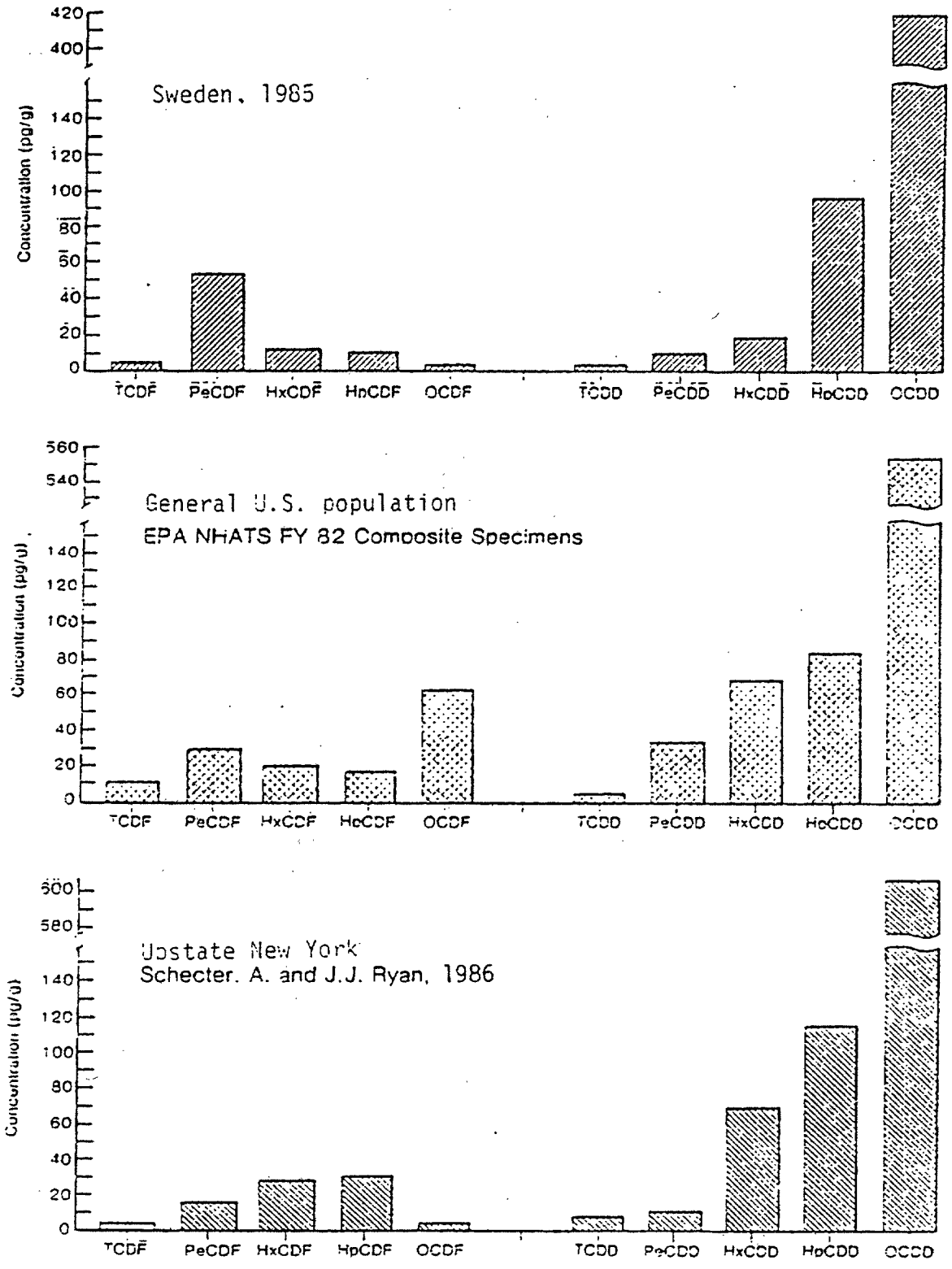

Figure 3. Comparison of PCDD and PCDF concentration (based on wet tissue weight) profiles for Sweden, the general U.S. population, and upstate New York (from top to bottom, respectively).
(Source: Stanley 1986; Schecter and Ryan 1986; Nygren et al. 1985)

The results of this phase of the broad scan analysis program demonstrate that the EPA NHATS program is an effective vehicle for documenting the exposure of the general U.S. population to PCDDs and PCDFs. The analysis of the 46 composite samples prepared from the FY82 NHATS repository establishes the prevalence of the 2,3,7,8,-substituted tetra- through octachloro-PCDD and PCDF congeners in the U.S. population.

The quantitative data for the PCDD and PCDF congeners presented in this report have been submitted along with all supporting quality control data to the OTS Design and Development Branch contractor, Battelle Columbus Division, for statistical analysis. These data will be analyzed to determine the significance of differences in PCDD and PCDF levels based on major demographic factors.

E. Trace Elements

The objective of this task was to provide EPA/OTS with (1) a preliminary assessment of multielement analytical techniques that are applicable for determining trace elements in adipose tissues and (2) a qualitative assessment of the level of the specific tissue elements that were present in selected specimens.

The analyses of nine selected adipose tissue specimens from the FY82 NHATS repository were completed using multielement techniques ICP-AES and NAA. A total of 18 elements were detected using the two techniques and the estimated tissue levels are reported. Tables 16 and 17 provide the results generated by ICP-AES and NAA for the nine adipose tissue specimens.

Elements determined by ICP-AES (Table 16) were aluminum, boron, calcium, iron, magnesium, sodium, phosphorus, tin, and zinc. The estimated detection limits for 20 additional elements determined by ICP-AES were also reported. Elements determined by NAA (Table 17) were bromine, chlorine, cobalt, iron, iodine, potassium, sodium, rubidium, selenium, silver, and zinc. The estimated detection limits for 56 additional elements determined by NAA were also reported. The results reported for iron, zinc, and sodium are comparable for the two methods.

The results of this study are compared with tissue data reported in a monograph prepared for the International Commission in Radiological Protection (ICRP) (Snyder et al. 1975). Data in the ICRP report are based on multiple sample analyses by single element techniques. The ICRP data were generated in the mid-1950s through the mid-1960s. The data for the FY82 NHATS specimens are generally comparable with the levels presented in the ICRP summary with the exception of tin. Tin was detected at concentration levels estimated to range from 4.6 to 15 µg/g in the NHATS specimens compared to 0.047 µg/g for the values reported for the ICRP report. These tin levels were generated by the ICP-AES analyses but were not confirmed by NAA.

Table 16. Concentration (μg/g) for Trace Elements in Adipose Tissue Determined by ICP-AES Analysis

Element	NHATS FY82 sample number								
	8202046	8204083	8110967	8200586	8206278	8201428	8201022	8205874	8202962
Aluminum, Al	1.3	3.2	4.1	4.3	ND(0.63)[a]	8.3	ND(0.63)	ND(0.63)	2.1
Boron, B	ND(0.32)	ND(0.32)	ND(0.32)	ND(0.32)	ND(0.32)	ND(0.32)	ND(0.32)	ND(0.32)	ND(0.32)
Calcium, Ca	19	26	15	26	16	41	19	15	16
Iron, Fe[b]	13	26	8.3	7.6	3.0	12	7.3	36	20
Magnesium, Mg	10	11	8.8	25	6.5	12	8.4	14	17
Sodium, Na[b]	540	640	280	380	240	430	150	240	270
Phosphorus, P	170	180	150	160	130	210	160	220	220
Tin, Sn	8.7	10	14	9.9	8.7	12	15	12	11
Zinc, Zn[b]	1.6	2.6	1.6	3.3	1.1	1.8	3.2	6.0	4.1

[a]ND = not detected. Value in parentheses is the estimated limit of detection.
[b]Refer to Table 17 for comparison of ICP-AES value with NAA measurement.

Table 17. Summary of Data for Trace Elements (μg/g) Identified in Nine Human Adipose Tissue Specimens by NAA

Element	Sample number								
	8202046	8204083	8110967	8200586	8206278	8201428	8201022	8205874	8202962
Gold, Au	ND(0.0025)[a]	0.0030	ND(0.0025)	0.0006	ND(0.0012)	ND(0.0032)	ND(0.0017)	ND(0.0018)	ND(0.0042)
Bromine, Br	0.62	0.94	1.0	0.80	1.6	2.4	0.74	0.99	0.33
Chlorine, Cl	550	1,500	360	580	380	480	240	370	410
Cobalt, Co	0.078	0.055	0.065	0.044	0.034	0.079	0.035	0.047	0.073
Iron, Fe[b]	9.6	7.7	6.3	9.3	3.5	14	6.3	40	26
Iodine, I	ND(1.9)	ND(8.6)	ND(6.0)	13	ND(1.5)	ND(3.4)	ND(1.4)	ND(3.1)	ND(2.5)
Potassium, K	95	250	90	200	52	110	180	270	200
Sodium, Na[b]	490	1,200	310	580	290	410	240	320	340
Rubidium, Rb	0.18	ND(1.1)	ND(0.73)	0.25	0.21	0.24	0.23	ND(0.61)	0.27
Selenium, Se	0.030	0.033	ND(0.082)	0.042	0.034	0.056	0.038	0.042	ND(0.11)
Silver, Ag	ND(0.16)	ND(0.12)	0.38	ND(0.13)	ND(0.14)	ND(0.16)	ND(0.13)	ND(0.13)	ND(0.12)
Zinc, Zn[b]	1.5	2.0	1.4	4.5	1.4	1.4	1.6	3.4	2.3

[a] ND = not detected. Value in parentheses is the estimated limit of detection.
[b] Refer to Table 16 for comparison of NAA value with ICP-AES measurement.

III. RECOMMENDATIONS

Specific recommendations based on analyte classification are discussed below.

A. Volatile Organic Compounds

Further analytical method development should be pursued to improve the determination of volatile organic compounds in human adipose tissue samples. These improvements should specifically include smaller sample sizes (1.0 to 5.0 g), more efficient transfer of volatile organics onto the HRGC column, and further development of the isotope dilution quantitation technique. These modifications can possibly be achieved by using widebore HRGC columns and/or cryofocusing techniques.

The analytical method should be modified to provide quantitative information on compounds of greater volatility than chloroform (such as methylene chloride, vinyl chloride, etc.). This possibly could be accomplished by conducting two analyses on each tissue sample. The first analysis should be conducted for the more volatile compounds with the sample heated in the range of 50-80°C and the headspace sampled for 15 min or less. The second sample analysis should be conducted with the procedures specified in this report to provide quantitative data for compounds ranging in volatility from chloroform through the dichlorobenzene isomers.

Stability studies should be conducted to determine the effects of long-term storage at subzero temperature, and repeated thawing and freezing on the integrity of the volatile organic content in the sample. The results of the sample analysis conducted for the FY82 composites indicate considerable differences in the absolute quantities of the major volatile constituents (hydrocarbons, aldehydes, ketones, etc.) for samples analyzed within 6 mo of collection and the NHATS specimens that had been archived prior to analysis for up to 2 yr.

B. Semivolatile Organic Compounds

The analytical method should be fully validated through additional intra- and interlaboratory analyses. This is necessary to fully define the method's limitations [accuracy, precision, limits of detection (LOD), and limits of quantitation (LOQ)], and quality control (QC) requirements for reporting valid data. The method LOD and LOQ for individual analytes should be determined experimentally through replicate analysis of spiked tissue samples. The HRGC/MS and PGC/ECD methods should be evaluated using homogenized split samples to determine the comparability of data for the organochlorine pesticides and PCB data. This is necessary to determine whether trend lines can be extended from existing PGC/ECD data from previous NHATS analysis programs.

Before proceeding with the validation and comparability studies, the analytical method should be modified to include at least two more internal standards for quantitation. Surrogate compounds that will fractionate in the more polar Florisil fractions are needed to fully evaluate method performance on a per sample basis. Deuterated phthalate esters that are commercially

available should be considered as surrogates in further evaluation of the analytical method.

There is a need to establish sufficient characterized reference samples for continued broad scan analysis projects for use as QC samples. These QC samples should be available in quantities comparable to the 20-g composited tissue samples. This type of QC sample could be developed from lipid materials extracted from human adipose tissues. The lipid materials should be thoroughly homogenized and the background levels of semivolatile organic analytes established through replicate analysis. Once this reference material has been characterized, it could be spiked with additional analytes for positive documentation of method performance.

Additional method development is needed to identify a more expedient means of removing bulk lipid from the samples. The current analytical methodology, although effective, requires considerable time and cost to prepare the samples.

There is a need to develop HRGC/selective detector analysis methods to generate data for target analytes on a routine basis. Specifically, HRGC/ECD analysis of adipose tissue could supply EPA/OTS with data for chlorobenzenes, organochlorine pesticides, and specific PCB isomers. This approach would require smaller sample sizes and result in more expedient sample preparation while maintaining the sensitivity to achieve 1-10 ng/g (ppb) detection levels. The approach of HRGC/selective detector analysis could also be used to monitor phosphate triesters on a routine basis.

Some consideration should be given to evaluation of alternate HRGC/MS techniques including SIM, negative chemical ionization MS, and mass spectrometry/mass spectrometry (MS/MS) to lower detection limits and increase specificity for compound classes such as organochlorine pesticides, polychlorinated biphenyls, polybrominated biphenyls, polychlorinated terphenyls, polychlorinated diphenyl ethers, and polychlorinated naphthalenes.

C. PCDD and PCDF

The methods described for PCDD and PCDF analysis were developed in conjunction with the HRGC/MS broad scan analysis method for determination of general semivolatile organic compounds in human adipose tissues. A continued effort in following PCDD and PCDF trends will require that the analytical method as described be fully validated through intra- and interlaboratory studies.

Certified standards other than the 2,3,7,8-TCDD are not currently available. It is imperative that the additional 2,3,7,8-substituted PCDD and PCDF congeners be made available as certified materials for future studies to allow accurate comparison of residue levels in the general population.

The analytical method should be modified to include additional carbon-13 labeled internal standards to improve the accuracy of the quantitation of the tetra- through octachloro PCDD and PCDF.

The time required for preparation of 10- to 20-g tissue samples by the method is time intensive as a result of bulk lipid removal by GPC. This procedure was necessary to achieve the overall objective of the broad scan analysis program. However, future studies that focus on PCDD and PCDF levels will require the development of more expedient sample preparation techniques.

D. Trace Elements

The study compared ICP-AES and NAA analysis for multielement determination in adipose tissue. It is recommended that the sensitivity, selectivity, and cost of each analysis technique be considered with respect to the trace elements of interest before proceeding with analysis of additional samples. The data collected from this preliminary scan of metals in adipose tissue demonstrate that ICP-AES has sufficient sensitivity to allow analysis of large numbers of adipose samples for multiple elements at a reasonable cost. However, modifications of the method are necessary to lower the detection limits. These modifications should include increasing the sample size and incorporating an acceptable approach for correcting background resulting from overlapping spectral interferences.

NAA has the advantage of detecting some elements not possible by ICP-AES such as the halogens, rubidium, and cesium. Although multielement analysis by NAA is much more expensive, it may provide the sensitivity and specificity needed to identify elements of interest.

One other analytical technique that should be considered is high temperature graphite furnace atomic absorption spectrometry. This technique can provide lower levels of detection but is limited to single element measurements. This technique can be evaluated for elements of special interest.

A study of possible interest to EPA would be the determination of elements directly associated with the lipid materials rather than the whole tissue. This could be accomplished by rendering the adipose tissue followed by multielement analysis of the oily materials. Based on the results of these studies further evaluation may be necessary to determine speciation of elements.

A national survey of human adipose tissue to determine prevalence of toxic trace elements will require stringent quality assurance practices. This will require method validation for each element of interest, development of a representative reference material, and integration of a minimum QC program that specifies the frequency of analysis of blanks, spiked tissues, and reference materials. A representative reference material can be generated by isolating and homogenizing lipid materials from tissues collected through the NHATS program. Repetitive analysis of such a reference material (spiked and unspiked) can provide the necessary data to document method precision and accuracy for all samples analyzed.

IV. REFERENCES

Lucas RM, Pierson SA, Myers DL, Handy RW. 1981. RTI. National Human Adipose Tissue Survey Quality Assurance Program Plan. Preliminary Draft. RTI/1864/21-11.

Mack GA, Stanley J. 1984. Preliminary strategy on the National Human Adipose Tissue Survey. Washington, DC: Office of Toxic Substances. Contracts 68-01-6721 (Task 21) and 68-02-3938 (Work Assignment 8).

Nygren M, Hansson M, Rappe C, Domellof L, Hardell L. 1985. Analysis of polychlorinated dibenzo-p-dioxins and dibenzofurans in adipose tissue from soft-tissue sarcoma patients and controls. 189th National ACS Meeting Symposium on Chlorinated Dioxins and Dibenzofurans in the Total Environment III, Miami, Florida, 1985. Washington, DC: ACS. 25:160-163 Paper No. 55.

Ryan JJ. 1986. Variation of dioxins and furans in human tissues and organ by country. Chemosphere 15:1585-1593.

Schecter A, Ryan JJ. 1986. Chlorinated dioxin and dibenzofuran levels in human adipose tissue from exposed and control populations. In: Chlorinated dioxins and dibenzofurans in perspective. Rappe C, Choudhary G, Keith LH, eds. Chelsea, MI: Lewis Publishers, pp. 51-66.

Snyder WS, Cook MJ, Nasset ES, Karhausen LR, Howells GP, Tipton IH. 1975. Report of the task group on reference man. Elmsford, NY: Pergamon Press. International Commission Radiological Protection (ICRP) Report No. 23.

Stanley JS. 1986a. Broad scan analysis of human adipose tissue: Volume II: Volatile organic compounds. EPA 560/5-86-036.

Stanley JS. 1986b. Broad scan analysis of human adipose tissue: Volume III: Semivolatile organic compounds. EPA 560/5-86-037.

Stanley JS. 1986c. Broad scan analysis of human adipose tissue: Volume IV: Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). EPA-560/5-86-038.

Stanley JS. 1985. MRI. Analytical method for the determination of semivolatile organic compounds in human adipose tissue. Interim Report, Revision No. 2. Washington, DC: Office of Toxic Substances. Contract 68-02-3938 (Work Assignment 8).

Stanley JS, Boggess KE, Onstot J, Sack TM, Remmers JC, Breen J, Kutz FW, Curra J, Robinson P, Mack GA. 1986. PCDDs and PCDFs in human adipose tissue from the EPA FY82 NHATS repository. Chemosphere 15:1605-1612.

Stanley JS, Stockton RA. 1986. Broad scan analysis of human adipose tissue: Volume 6: Trace elements. EPA-560/5-86-039.

APPENDIX A

GLOSSARY OF TERMS

FY82	Fiscal year 1982
HpCDD	Heptachlorodibenzo-p-dioxin
HpCDF	Heptachlorodibenzofuran
HRGC	High resolution gas chromatography
HxCDD	Hexachlorodibenzo-p-dioxin
HxCDF	Hexachlorodibenzofuran
ICP-AES	Inductively coupled plasma-atomic emission spectroscopy
ICRP	International Commission Radiological Protection
MS	Mass spectrometry
NAA	Neutron activation analysis
NHATS	National Human Adipose Tissue Survey
NHMP	National Human Monitoring Program
OCDD	Octachlorodibenzo-p-dioxin
OCDF	Octachlorodibenzofuran
OTS	Office of Toxic Substances
PCDD	Polychlorinated dibenzo-p-dioxin
PCDF	Polychlorinated dibenzofuran
PeCDD	Pentachlorodibenzo-p-dioxin
PeCDF	Pentachlorodibenzofuran
SIM	Selected ion monitoring
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran